Modeling Plankton Productivity and Nutrient Cycling in the Black Sea: Simulations with a 1-D Vertically Resolved, Coupled Physical-Biochemical Model

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The annual cycle of the plankton dynamics in the central Black Sea is studied by a one-dimensional vertically resolved physical-biochemical upper ocean model, coupled with the Mellor-Yamada level 2.5 turbulence closure scheme. The biological model involves interactions between the inorganic nitrogen (nitrate, ammonium), phytoplankton and herbivorous zooplankton biomasses, and detritus. Phytoplankton are represented in two groups formed by *small* ($< 20\mu m$) and *large* ($> 20\mu m$) cells. Herbivores are also separated in two groups as *microzooplankton* ($< 200\mu m$) and *mesozooplankton* ($0.2-2mm$). The model further incorporates nitrification, denitrification and vertical advection processes to provide a realistic representation of the nitrogen cycling and biological pump within the upper layer water colum.

Given a knowledge of physical forcing, the model simulates main observed seasonal and vertical characteristic features; in particular, formation of the cold intermediate water mass and yearly evolution of the upper layer stratification, the annual cycle of production with the fall and the spring blooms, the subsurface phytoplankton maximum layer in summer, as well as realistic patterns of particulate organic carbon and nitrogen. The computed seasonal cycles of the chlorophyll and primary production distributions over the euphotic layer compare reasonably well with the data.

Initiation of the spring bloom is shown to be critically dependent on the water column stability. It commences as soon as the convective mixing process weakens and

before the seasonal stratification of surface waters begins to develop. It is followed by a weaker phytoplankton production at the time of establishment of the seasonal thermocline in April. While summer nutrient concentrations in the mixed layer are low enough to limit production, the layer between the thermocline and the base of the euphotic zone provides sufficient light and nutrient to support subsurface phytoplankton development. The late spring and summer plankton productivity may vary from one continuous bloom episode during most of the summer period to a chain of successive shorter term events. Realization of any one of these cases depends on particular combinations of choices of the growth and grazing rates characterizing dominant species of the phytoplankton and zooplankton groups. The autumn bloom takes place some time between October and December depending on environmental conditions. In the case of weaker grazing pressure to control the growth rate, the autumn bloom shifts to December-January and emerges as the winter bloom, or in some cases, is connected with the spring bloom to form one unified continuous bloom structure during the January-to-March period. These bloom structures are similar to the year-to-year variabilities present in the data.

The annual nitrogen budget for the euphotic zone shows that nearly 60% of the primary production is supported by ammonium. Half of the nitrate-based production is new production supplied by the vertical advection and diffusion, whereas the other half is originated from recycling within the euphotic layer as a result of the remineralization-ammonification-nitrification chain. More than 90% of the ammonium-based production also comes from nitrogen recycling within the euphotic layer.

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MODELLING THE ROLE OF ZOOPLANKTON IN IN THE MARINE FOOD CHAIN

12 - 16 August 1996

Monday 12 August

09:00 - 10:30	Registration
10:30 - 11:00	Coffee
11.00 - 11.30	Welcome and Introduction *John Brindley (Leeds) and Jacquie McGlade (Warwick)*
11:30 - 12:00	The international GLOBEC programme *Roger Harris (Plymouth Marine Laboratory)*
12:10 - 12:30	The GLOBEC numerical modelling working group *Mike Fasham (Southampton Oceanography Centre)*
12:30 - 14:00	Lunch
14:00 - 14:30	Structured population models for marine zooplankton *Eileen Hofmann (Old Dominion University)*
14:30 - 15:00	The effect of age structure on a general plankton ecosystem *Robin Clother (Leeds)*
15:00 - 15:30	Structured *versus* unstructured modelling of planktonic populations *Marcus Kirkilionis (CWI Amsterdam)*
15:30 - 16:00	Tea
16:00 - 16:30	The swimming of plankton organisms: should it be taken seriously? *John Kessler (Arizona)*
16:30 - 17:00	Life stage-based model of interacting species of copepods: consequences on the formulation of grazing and predation in a zooplankton model *Francois Carlotti (Station Zoologique, Villefranche)*
17:00 - 17:30	Modelling copepod production in the Irish Sea *Meryl Prestidge (Plymouth Marine Laboratory)*
17:45	Wine reception